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# Nickel-Hydrogen Battery Technology—Development and Status

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**A history of the development of the nickel-hydrogen ($Ni-H_2$) technology at COMSAT Laboratories is presented, starting with the initial exploratory effort in 1970 and extending to the present INTELSAT V $Ni-H_2$ batteries. The latter are based upon the proven reliability of the NTS-2 $Ni-H_2$ cell design and the manufacturing procedures developed to fabricate these cells. This paper compares four different $Ni-H_2$ batteries: the NTS-2 battery, the INTELSAT V flight battery, a 50-A-h battery, and a high-pressure 50-A-h battery. Although all these batteries use the same baseline cell design, the length of the pressure vessel and number of modules in the electrode stack are varied to achieve the desired ampere-hour capacity. Comparisons are made with respect to specific energy, energy per unit volume, structural design, and heat-transfer capability. The maximum specific energy achieved was 60.1 W-h/kg for the high pressure 50-A-h cell.**

## Introduction

EXPLORATORY research and development of hermetically sealed $Ni-H_2$ cells was started at COMSAT Laboratories in 1970 based upon an original invention.[1] Once initiated, this technology advanced very rapidly from the initial experimental proof-of-concept phase to the development phase. The basic concepts were verified using a variety of available electrode stack components. Since the sealed $Ni-H_2$ cell is a hybrid combining battery and fuel-cell technologies, components were available from both technologies for use during the early experimental work. For example, nickel-oxide electrodes were taken from aerospace nickel-cadmium (Ni-Cd) cells, and platinum black hydrogen electrodes were taken from hydrogen-oxygen fuel cells; both battery and fuel cell types of separator materials were used. Performance of these experimental cells, combined with the very favorable electrochemistry of the system, indicated significant potential advantages of $Ni-H_2$ over Ni-Cd batteries for communications satellite applications.

After the validity of the principle was demonstrated, a research and development program was started with INTELSAT funding to develop a 50-A-h $Ni-H_2$ cell. The following major development areas were included:

1) Design of a 50-A-h cell.
2) Investigation of lifetime limiting mechanisms.
3) Development of a hermetically sealed pressure shell.
4) Development and optimization of the electrode stack components.

By 1975, the technology had advanced sufficiently to warrant a flight demonstration of an $Ni-H_2$ battery. INTELSAT and the Naval Research Laboratory (NRL) entered into an agreement whereby COMSAT would provide NRL with 35-A-h $Ni-H_2$ cells for use on the U.S. Navy Technology Satellite (NTS-2) spacecraft. This program united all the previous development efforts and culminated in a very reliable $Ni-H_2$ cell design. A cross-sectional view is shown in Fig. 1.

Salient features of the NTS-2 cell design are the following:

1) Inconel 718 pressure vessel with plastic compression seals at each end for the negative and positive terminals.
2) Electrochemically impregnated positive nickel-oxide electrodes (Bell Laboratories aqueous process) in a back-to-back design.
3) Asbestos separator material.
4) Platinum black negative electrodes with teflon backing.

The NTS-2 battery was the first $Ni-H_2$ battery in space and has performed exceptionally well to date.[2] Results from the NTS-2 flight demonstration combined with laboratory test data showed that $Ni-H_2$ batteries offer significant advantages over Ni-Cd batteries for commercial geosynchronous satellites. As a result of these efforts, $Ni-H_2$ batteries are now scheduled for use on board the INTELSAT V F-4, F-5 and F-6 spacecraft and are proposed for the INTELSAT V-A program. INTELSAT V will provide the first application of $Ni-H_2$ batteries on board an operational communications satellite and will represent a significant accomplishment for COMSAT Laboratories.

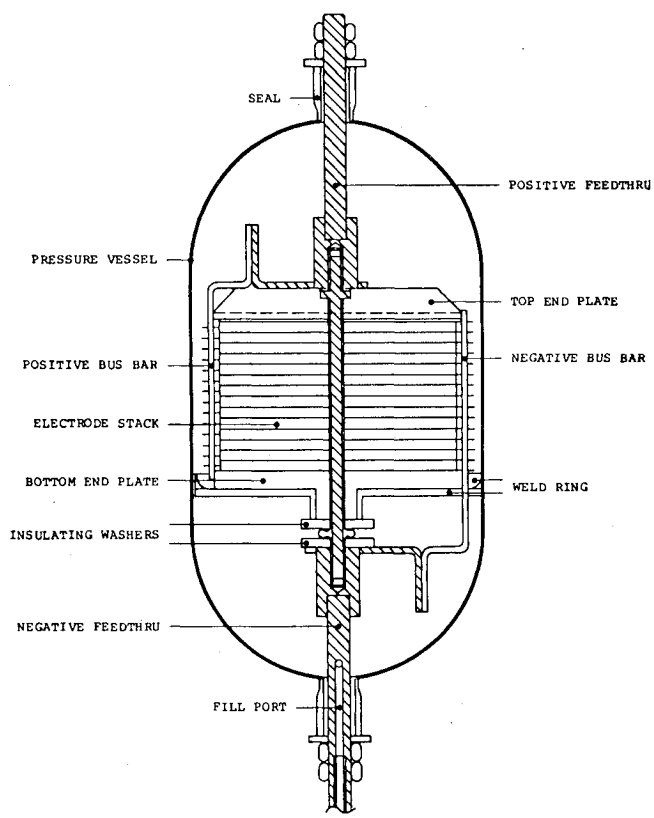


**Fig. 1 Cross-sectional view of NTS-2 $Ni-H_2$ cell.**

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